



**Note: Assume any data required, state your assumption clearly.  
 Answer all questions**

**Question (1) (25 Marks)**

- 1-a) Define the following notations:  $D_{30}$ ,  $D_{20}$  and  $D_{32}$  (6 Marks)
- 1-b) Calculate the sphericity of a cube and Tetrahedron each of side length,  $l=10$  mm (4 Marks)
- 1-c) Discuss only four methods for particle size measurement. (4 Marks)
- 1-d) The equations giving the number distribution curve for a powdered material are  $dn/dd = d$  for the size range  $0-10 \mu\text{m}$  and  $dn/dd = 10^5/d^4$  for the size range  $10-100 \mu\text{m}$  where  $d$  is in  $\mu\text{m}$ . Sketch the number, surface and mass distribution curves and calculate the surface mean diameter for the powder. Explain briefly how the data required for the construction of these curves may be obtained experimentally. (11 Marks)

**Question (2) (25 Marks)**

- 2-a) Explain the difference between separation and grade efficiencies and show using graph the importance of  $d_{50}$  and  $d_a$ . (4 Marks)
- 2-b) Differentiate between degree of mixing and rate of mixing. (4 Marks)
- 2-c) The performance of a solids mixer was assessed by calculating the variance occurring in the mass fraction of a component amongst a selection of samples withdrawn from the mixture. The quality was tested at intervals of 30 s and the data obtained are:

sample variance (-)	0.025	0.006	0.015	0.018	0.019
mixing time (s)	30	60	90	120	150

If the component analyzed represents 20 per cent of the mixture by mass and each of the samples removed contains approximately 100 particles, comment on the quality of the mixture produced and present the data in graphical form showing the variation of the mixing index with time. (10 Marks)

- 2-d) The collection efficiency of a cyclone is 45 per cent over the size range  $0-5 \mu\text{m}$ , 80 per cent over the size range  $5-10 \mu\text{m}$ , and 96 per cent for particles exceeding  $10 \mu\text{m}$ . Calculate the efficiency of collection for a dust with a mass distribution of 50 per cent  $0-5 \mu\text{m}$ , 30 per cent  $5-10 \mu\text{m}$  and 20 per cent above  $10 \mu\text{m}$ . (7 Marks)

**Question (3) (25 Marks)**

- 3-a) Explain using neat sketches the working principles of the settling tank, the elutriator, the Spitzkaster and the double cone classifier. (8 Marks)
- 3-b) The size distribution by mass of the dust carried in a gas, together with the efficiency of collection over each size range, is as follows:

Size range ( $\mu\text{m}$ )	0-5	5-10	10-20	20-40	40-80	80-160
Mass (per cent)	10	15	35	20	10	10
Efficiency (per cent)	20	40	80	90	95	100

Calculate the overall efficiency of the collector, and the percentage by mass of the emitted dust that is smaller than  $20 \mu\text{m}$  in diameter. If the dust burden is  $18 \text{ g/m}^3$  at entry and the gas flow  $0.3 \text{ m}^3/\text{s}$ , calculate the mass flow of dust emitted. (8 Marks)

- 3-c) A finely ground mixture of galena and limestone in the proportion of 1 to 4 by mass is subjected to elutriation by an upward-flowing stream of water flowing at a velocity of  $5 \text{ mm/s}$ . Assuming that the size distribution for each material is the same, and is as shown in the following table, estimate the percentage of galena in the material carried away and in the material left behind. The viscosity of water is  $1 \text{ mN s/m}^2$  and Stokes' equation ( $C_d = 24/Re$ ) may be used.

Diameter ( $\mu\text{m}$ )	20	30	40	50	60	70	80	100
Undersize (% by mass)	15	28	48	54	64	72	78	88

The densities of galena and limestone are  $7500$  and  $2700 \text{ kg/m}^3$ , respectively. (9 Marks)

**Question (4)**

**(25 Marks)**

1- Define the following:

- Dryness fraction and mass flow ratio
- Velocity ratio, slip and drift velocity
- Void and liquid volume fraction
- Superficial phase velocities

2- Draw the following flow patterns:

Horizontal pipe flow, vertical upward pipe flow - vertical downward pipe flow

3- An air water mixture flows through a smooth horizontal 20 mm bore pipe. The mass velocity of the mixture is  $1791 \text{ kg/m}^2\cdot\text{s}$  and the dryness fraction is 0.001. Assume that the velocity ratio  $k = (v_H/v_L)^{0.5}$ . The physical properties are  $v_G = 0.84 \text{ m}^3/\text{kg}$ ,  $v_L = 0.001 \text{ m}^3/\text{kg}$ ,  $\mu_L = 0.1002 \times 10^{-3} \text{ N}\cdot\text{s}/\text{m}^2$ ,  $\mu_G = 1.789 \times 10^{-5} \text{ N}\cdot\text{s}/\text{m}^2$  and the single-phase friction factor is  $\lambda = 0.186/\text{Re}^{0.2}$ . Evaluate:

- a) the superficial velocities of the phases.
- b) the velocity ratio.
- c) the phases cross sectional ratios  $\alpha$  and  $\alpha_L$
- d) the phase velocities and the homogenous velocity.
- e) the slip and the drift velocities.
- f) the mixture density and the homogenous density.
- g) the single phase Reynolds numbers  $\text{Re}_{LO}$ ,  $\text{Re}_L$ ,  $\text{Re}_{GO}$ ,  $\text{Re}_G$
- h) the excess dimensionless pressure drop.
- i) the normalized two-phase multiplier.

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**GOOD LUCK**

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